EXECUTIVE SUMMARY

The new set of wireless, Personal Communications Services (PCS) now being considered by the FCC promises to spawn a wide range of new, affordable telecommunications services, while bringing needed competition to cellular and wireline operators. To fulfill this promise requires, among other things, a regulatory regime which expedites system deployment, facilitates effective competition and promotes the development of a network infrastructure that minimizes subscriber costs and maximizes quality.

An essential ingredient of such a regulatory regime is the assignment of ample spectrum to PCS licensees. Because it both facilitates prompt initiation of service through spectrum sharing with existing microwave users and places the coverage, capacity and cost of PCS systems on par with competing cellular operations, a 40 MHz PCS assignment plan offers the minimum bandwidth necessary to achieve all these important social and business objectives.

Moreover, policies which parse the allocation into 20 MHz blocs but permit operators to assemble greater bandwidth by aggregating individual assignments would not promote the public interest. Despite its political attractiveness, such an approach would slow and make more expensive the initiation of service while reducing significantly auction revenues. A better method would be to permit 40 MHz assignments to be "dis-aggregated"; that is, to allow licensees of 40 MHz blocs to assign portions of their spectrum to other parties, as appropriate.

PCS ASSIGNMENT BANDWIDTH AND THE PUBLIC INTEREST

by

Alex D. Felker[1]

I. INTRODUCTION

The creation of a new set of wireless, Personal Communications Services (PCS) by the Federal Communications Commission promises to spawn a wide range of innovative telecommunications services, affordable to average Americans, while bringing needed competition to cellular and wireline operators. However, the realization of this promise requires, among other things, a regulatory regime which facilitates effective competition and promotes the development of a network infrastructure that minimizes subscriber costs and maximizes coverage and quality.

This paper examines a crucial element of such a regime -- the assignment of ample bandwidth to PCS operators -- and

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concludes that PCS assignments should be no smaller than 40 MHz.[2] As discussed in the following section, because the frequencies being allocated to personal communications services are now being used by thousands of fixed microwave systems, PCS assignments of at least 40 MHz are required to facilitate prompt initiation of service through spectrum "sharing." Moreover, as examined in Section III, at least 40 MHz of clear spectrum is required to place the coverage, capacity and cost of PCS systems on par with competing cellular systems. Section IV considers the efficiency and public policy advantages of assigning PCS operators a single 40 MHz license directly rather than adopting a policy that would require licensees to assemble sufficient bandwidth through the aggregation of smaller assignments. Section V summarizes the conclusions reached in the earlier sections and examines their public policy implications.

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[2] The establishment of PCS assignment bandwidths of at least 40 MHz is supported by a number of factors. In addition to the grounds examined in this paper, 40 MHz assignments are also required to support the higher data rates needed to make PCS voice and data services competitive with existing and planned wire and wireless networks and reduce infrastructure costs by increasing trunking efficiency and decreasing the need for higher levels of frequency reuse.

II. THE RELATIONSHIP BETWEEN PCS BANDWIDTH AND SPECTRUM SHARING WITH INCUMBENT MICROWAVE SYSTEMS

The FCC has allocated 220 MHz of the 1850-2200 MHz band to "emerging technologies,"[3] and, based on informal conversations with Commission staffers, it appears that PCS will receive approximately 160 MHz of that allocation.[4] The portions of the "emerging technologies band" that likely will be allocated to PCS (1850-1970, 2130-2150, 2180-2200 MHz) now are home to roughly 20,000 private fixed microwave links. Although the FCC has adopted a plan under which some (but not all) of these links can be relocated to other bands or media,[5] this transition is expected to take no less than three years to accomplish. Moreover, because certain public safety links are grandfathered permanently, some of these fixed facilities will be in operation for the indefinite future.

At least for the foreseeable future, therefore, PCS operators will have to "share" the spectrum with incumbent microwave facilities. The need to protect these existing operations from interference can limit significantly both the

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[3] See First Report and Order and Third Notice of Proposed Rule Making, ET Dkt. No. 92-9, 7 FCC Rcd 6886 (1992).

[4] Of that 160 MHz, it is anticipated that 40 MHz will be set aside for unlicensed operations.

[5] See Procedures Adopted for Emerging Technology Access to 2 GHz Spectrum, FCC ET Dkt. No. 92-9 (News Release July 15, 1993).

amount of spectrum usable for PCS and the areas in which wireless service can be offered. The size of the bandwidth assigned to individual operators, relative to the bandwidth assigned to microwave systems, will affect substantially the degree to which this sharing can be accomplished in a fashion consistent with the creation of a successful business.

A. Microwave Channelization

1850-1990 MHz Band. As illustrated in Figure 1, the existing 1850-1990 MHz Private Operational Fixed Service (POFS) microwave band is parsed into 10 MHz channels.[6] A very large number of these are two-way communication links, and, therefore, the facilities employ pairs of channels that are separated by 80 MHz.[7] Note, also, that the frequencies between 1900 and 1920 MHz are not paired and are intended for one-way communications circuits.

2130-2150/2180-2200 MHz Bands. In contrast to the lower frequency band, the 2130-2150/2180-2200 MHz POFS bands are divided into **800 kHz** channel pairs, separated by **50 MHz**. In this

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[6] Although the FCC authorizes 5 MHz operation on some of these channels, a very large proportion of the licensed microwave facilities in this band employ 10 MHz channels.

[7] For example, POFS channels designated "1" in Figure 1 (1850-1860 MHz/1930-1940 MHz) represent a "pair" and are separated by 80 MHz.

band, the FCC allows the formation of 1.6 MHz bandwidths through the combination of two 800 kHz channels.

B. PCS Bandwidth and Spectrum Sharing

New microwave systems are required to avoid interfering with existing operations. The degree of interference caused by a new microwave station is a function of a number of factors including, power, antenna height, and distance between existing and proposed systems. Moreover, because these systems frequently employ highly directive antennas, interference is also a function of the extent to which a protected receiving antenna and interfering transmitting antenna would point towards each other.

Likewise, new PCS systems will have to be designed to prevent any potential interference to existing links by either base or mobile stations. Unfortunately, current microwave protection criteria would new personal communications systems to coordinate with all existing microwave receivers within **250 miles**.[8] Thus, a single existing microwave system can preclude PCS operation on a block of spectrum throughout an entire market.

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[8] An industry accepted set of technical criteria is used to analyze proposed operations and help engineers design new systems. These technical standards currently are being revised to take into account PCS operations. However, these standards, as they are constituted currently, could require the consideration by a new PCS operator of all microwave systems within 250 miles.

1. 1850-1990 MHz Band

Studies have found that there is a substantial number of unassigned channels in the 1850-1990 MHz POFS band. However, when the band is divided into discreet assignment blocks, and interference protection criteria are applied, the amount of spectrum available to a given operator within a particular market may be reduced substantially. Numerous market studies have found that coverage is perhaps the most important element of consumers' decisions to subscribe to PCS.[9] Therefore, fundamental to the creation of a business, PCS operators must provide ubiquitous service within their coverage areas. Consequently, even to initiate service, pieces of spectrum, on which PCS operation will not generate interference, must be identified in essentially all areas of a market. If there are regions in which no "clear" spectrum exists, these must be opened up by re-assigning one or more microwave systems to another frequency band (or other medium) before any service can be initiated.

Even though the 1850-1990 MHz POFS channels are spaced 10 MHz apart, the bandwidth of the receivers employed in these links may have larger bandwidths (typically on the order of 14 MHz). This means that energy on frequencies adjacent to the operating channel can create interference. Consequently, it is common practice for new microwave systems to avoid operation on channels

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[9] See PCS Trial Results: A Telocator Survey 1 (1993).

adjacent to existing systems already operating in the local area. Channel pairs 1, 3 and 5 shown in Figure 1 might be operational in a particular locale, for example, while 2, 4 and 6 remain unassigned.

Licensees of PCS systems with 40 MHz assignments (represented by assignments "I", "II" and "III" in Figure 1) can take at least limited advantage of this condition to minimize the number of microwave systems which must be removed initially by designing their system around existing facilities. By referring to Figure 1, one can see that, under the example presented in the previous paragraph, a PCS licensee assigned channel I could employ a portion of the upper half of its assignment and avoid interference with microwave systems operating on channel 1. PCS licensees assigned channels II and III could take a similar tact.

Note, however, that licensees of PCS systems with 20 MHz assignments (represented by assignments "A", "B", "C", "D", "E" and "F" in Figure 1) do not provide the same flexibility. Indeed, the use of POFS channel 1 anywhere in the service area of a PCS licensee with assignment A must be removed before any service can begin. A similar situation exists with PCS licensees with assignments B, C, D, E and F and the corresponding POFS microwave channels.

At first glance, it might appear that a 30 MHz PCS assignment plan could provide nearly as much flexibility to initiate PCS service as a 40 MHz assignment plan. Because of the

wider-than-10 MHz microwave receiver bandwidths, however, the amount of usable traffic-handling capacity available on unassigned adjacent channels may be small or non-existent under a 30 MHz plan.[10] Moreover, because a single POFS channel would be within the domain of two PCS licensees, relocation negotiations frequently would involve three parties, two of which were competitors. Because a potential information requirement of such negotiations would be technical data from which business plan inferences could be drawn, microwave relocation might be more drawn out than would otherwise be the case. Ultimately, consumers would suffer from lack of service.

A number of companies have conducted studies of the degree to which incumbent microwave operations would block the deployment of PCS in various cities and under various assignment bandwidths. One, conducted by American Personal Communications, found that assignments of 20 MHz and even 30 MHz would yield too little usable spectrum to permit PCS to be deployed.[11]

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[10] This outcome could obtain because the small amount of adjacent channel spectrum usable for PCS would have to be divided and coordinated between operators. Because of lower trunking efficiencies, the few resulting traffic channels could support significantly less subscriber volume than under a 40 MHz assignment plan.

[11] See American Personal Communications, Report on Spectrum Availability for Personal Communications Services Sharing the 1850-1990 MHz Band with the Private Operational Microwave Service (Gen. Docket 90-314 & ET Docket 92-9, November 1992).

In New York, for example, a 40 MHz assignment plan would result in each licensee, on average, having no spectrum available for PCS in 11.8% of the city's area. Although this congestion presents difficulties, it can be addressed effectively through the limited relocation of specific microwave systems. However, a 30 MHz plan compounds the microwave blockage significantly, increasing to 20% the average area precluded from PCS, and a 20 MHz plan results in nearly 30% of the city's area being precluded from PCS absent significant relocation of microwave systems. Los Angeles and Chicago present even worse results. A summary of the results for all cities examined in this study is presented in Table I.

TABLE I

Percentage of Areas with No Spectrum Available for PCS (No microwave links relocated)

City	2 Lic/40 MHz	3 Lic/30 MHz	5 Lic/20 MHz
New York	11.8%	20.0%	29.7%
Los Angeles	25.8%	30.6%	46.3%
Chicago	20.8%	30.1%	43.2%
Washington, DC	1.0%	4.7%	9.6%
Philadelphia	4.8%	11.0%	18.8%
Detroit	6.0%	10.2%	16.3%
Boston	3.7%	6.7%	13.1%
Dallas	13.4%	18.0%	32.1%
Houston	19.8%	25.7%	36.5%
Miami	10.2%	12.6%	26.3%
San Francisco	17.9%	24.7%	35.9%
Average	12.3%	17.6%	28.0%

A study conducted by Comsearch, a leading microwave coordination engineering firm, examined the number of microwave relocations that a demand-driven PCS deployment would require at various points in time, under 20 MHz, 30 MHz and 40 MHz

assignment plans.[12] The study examined one market, Detroit, and reached several important conclusions:

1. The 40 MHz plan requires 82% and 67% fewer initial microwave relocations than the 20 or 30 MHz plans, respectively;

2. The 40 MHz plan requires the least initial relocation of public safety microwave systems;

3. The 20 MHz plan requires 50% of the existing links (including 100% of the public safety systems) to be removed three years after licensing to create capacity sufficient to meet demand.

These conclusions have been challenged by cellular interests based on two additional Comsearch analyses of microwave sharing in the Detroit market.[13] One of these reports, commissioned by Bell Atlantic, has been relied on in subsequent papers: one which disputed Comsearch's contention that 40 MHz assignments were needed to facilitate early introduction of PCS with a minimum of initial relocation of microwave operations,[14] and another which

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12 See "Spectrum Allocations and Their Impact on Microwave User Relocations: A Case Study," Stephen M. Aspell, Comsearch, April 1993.

13 See, "Analysis of a 20 MHz PCS Spectrum Allocation for Detroit," (undated) and "Spectrum Allocations and Their Impact on Microwave User Relocations: A CDMA Study of Detroit. Sponsored by: GTE," Stephen M. Aspell, August 17, 1993.

14 See "Sharing Spectrum Between PCS and Microwave Systems," Dr. Charles Jackson and Professor Raymond Pickholtz, August 1993

flatly concluded that the Comsearch conclusions were "invalid."[15]

It would appear that the Jackson/Pickholtz and CTIA reports add little value to the policy debate regarding the benefit of 40 MHz assignments to promoting early initiation of PCS service, however.[16] As Comsearch itself indicated in a point-by-point address of the issues raised in the CTIA report, the results of all its studies are "thoroughly compatible with" the proposition that a 40 MHz "allocation will facilitate deployment of PCS in consideration of having to share spectrum with incumbent microwave users."[17]

2. 2130-2150/2180-2200 MHz Band

Inasmuch as the POFS channels in the 2130-2200 MHz band have only recently been identified as potential PCS allocations, no quantitative analysis has been conducted regarding the extent to which interim PCS/microwave sharing can be accomplished here. It is understood, however, that there exist approximately 13,000

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[15] See "Justifying 40 MHz PCS Allocations: 'Study' Was Based on Invalid Assumptions," Cellular Telecommunications Industry Association (CTIA), August 25, 1993.

[16] The April Comsearch study whose assumptions these reports decried found that a 40 MHz assignment required the initial relocation of 3 incumbent microwave links while a 20 MHz assignment need 14 operations relocated. Far from refuting these findings, the GTE Comsearch study concludes that relocation of even more incumbent operations would be required: 5 for a 40 MHz assignment scheme and 22 under a 20 MHz plan.

[17] See Letter to Lois Irwin from H. Mark Gibson, Senior Engineer, PCS Development, Comsearch, August 30, 1993.

licensed links in this band and that a mix of 800 and 1600 kHz bandwidths are employed.

Despite the lack of hard analysis, based on the parameters recounted above, some general inferences can be made concerning the promising potential for converting these band segments to PCS use. First, because the microwave bandwidths in these bands are at least a factor of ten narrower than in the 1850-1990 MHz band, it is not unreasonable to assume that the same degree of sharing can be accomplished with smaller PCS assignment bandwidths.

Second, to the extent some links in the 2130-2200 MHz band segments must be removed prior to the start of wireless service, their relatively narrow bandwidths make possible the use of wireline circuits as a substitute for radio links, at least on a temporary basis. Such a possibility could provide a faster means of shutting down particular links and could make negotiations easier with microwave licensees.

Finally, the number and characteristics of the existing fixed links suggest that the magnitude of any problems due to "hold outs" may be reduced relative to the lower bands. This factor could result in the time and expense of clearing these band segments being less than that required in the 1850-1970 MHz band.

Despite the promising nature of the preceding observations, however, it is important to recognize that the significant difference in the frequency spacing between the 1850-1990 and

2130-2200 MHz bands presents the very strong possibility that equipment compatibility will not exist between PCS operations in the two bands. Consequently, it may make sense to establish policies which lead to operations in the two bands being segregated naturally from a business perspective. Thus, for example, large area assignments could be grouped together in the 1850-1970 MHz band, and small area assignments could be made in the 2130-2200 MHz band segments.

C. Conclusion

In many large markets, PCS operators initially will have to share spectrum with incumbent microwave licensees. Generally, the larger the relative PCS assignment bandwidth the greater the opportunity for successful sharing. However, this relationship is not linear. Indeed, among the relevant choices of assignment bandwidths (20, 30 and 40 MHz), 40 MHz appears to be a substantially better choice for the 1850-1970 MHz band than either 30 MHz or 20 MHz assignment plans. In the band segments between 2130-2200 MHz being considered for PCS, narrower microwave bandwidths could result in better PCS conversion prospects.

III. TO ESTABLISH COVERAGE AND CAPACITY PARITY, PCS REQUIRES GREATER BANDWIDTH THAN CELLULAR

A key determinant of the prices charged for wireless telecommunications will be the capital cost of the underlying infrastructure. To both be a source of affordable wireless communications and compete effectively with incumbent networks, new PCS operators' infrastructure costs must be on par with those of competing cellular systems for comparable levels of coverage and capacity. To achieve such comparability, however, the very significant differences in the physical properties of the cellular and PCS frequency bands must be mitigated. As discussed below, these differences can be offset by assigning PCS operators significantly more spectrum than the 25 MHz each cellular carrier is assigned in the 800 MHz band.

A. Physical Relationship Between Coverage and Capacity

As a theoretical matter, the maximum capacity of a communications channel[18] is a function both of the channel's bandwidth and of the ratio, at the receiving end, of desired signal power to undesired interference and noise power. The basic concept has two parts: the larger the "pipe" the easier it is to push information through, and the stronger the signal the higher the quality of reception. The underlying mathematical

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[18] I.e., the data rate at which the incidence of errors can be made arbitrarily small.

relationship illustrates that capacity and coverage (i.e., signal-to-noise ratio) are inversely related and that, within certain ranges, bandwidth and coverage can be substituted for one another without sacrificing channel capacity.[19]

B. Differences Between Cellular and PCS Spectrum

As a general matter, signals at higher frequencies propagate more poorly than those at lower frequencies. All other things being equal, this property of radio propagation acts to reduce the coverage and/or the capacity of 2 GHz systems relative to those operating on 800 MHz. Moreover, short term signal fading appears to be much worse at 2 GHz. Consequently, with comparable transmitted powers, channel bandwidths and information signals, the coverage area of a 2 GHz PCS station can be expected to be between 1/2 and 1/4 that of an 800 MHz cellular station.[20]

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[19] Maximum capacity, C (in bits per second), of channel impaired only by "white" noise is defined as,

$$C = W*\log_2(1 + S/N)$$

where,

W = bandwidth in Hz
S = desired signal power
N = undesired noise power

[20] Numerous field tests confirm that transmission attenuation at 2 GHz is much greater than at 800 MHz. See, for example, results of extensive propagation field studies which Time Warner Telecommunications has conducted as summarized in Further Supplement to Request for Pioneer's Preference and Sixth Quarterly Report, September 30, 1992.

C. PCS/Cellular Parity and How to Achieve It

One can define "parity" between cellular and PCS in economic terms. Under this definition, systems in the two bands are on par if, with infrastructures of roughly comparable cost, each can deliver essentially equivalent service over similar geographic regions. Because of the poorer propagation properties at the higher frequencies, however, with equivalent assignment bandwidths, at least four times as many 2 GHz base stations are needed to deliver service comparable to 800 MHz cellular. Under these conditions, parity clearly would not exist between PCS and cellular systems.

As is evident from the definition of channel capacity, this disadvantage theoretically can be mitigated partially by employing wider PCS channel bandwidths to deliver the same quantity of information as cellular. Alternatively, smaller quantities of PCS traffic can be delivered over channel bandwidths comparable to cellular.[21] Although in analog

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[21] See Guy Jouannelle and Arun Jalan, Compensating for the Differences Between 800 MHz and 1800 MHz Wireless Telecommunications Systems: A Preliminary Analysis, LCC Incorporated (September 1993). This report quantifies many of the factors which contribute to the differences between the frequencies allocated to cellular and PCS and examines various means of compensating for them. The report concludes that increasing the bandwidth assigned PCS operators, relative to the 25 MHz assigned to each cellular licensee, is an effective means of putting 1800 MHz and 800 MHz systems on a more equal footing. The report further concludes that PCS assignments of 50 MHz would go a long way toward establishing equivalence with cellular in terms of coverage, capacity and infrastructure costs.

systems the tradeoffs may be somewhat difficult to accomplish, in digital systems some substitution between bandwidth, capacity and coverage is both possible and practical.

For example, the Qualcomm CDMA digital system being developed for PCS and cellular permits coverage and capacity to be traded off against each other continuously.[22] Paper analyses and field tests of the Qualcomm system suggest that the substantial coverage difference between 2 GHz and 800 MHz can be reduced substantially by operating at traffic loading levels half or less of maximum capacity.[23] Under these conditions, to achieve the same quantity of traffic capacity (at the edge of cell's coverage) as a fully loaded cellular Qualcomm system, a PCS operation would require at least 100% more bandwidth (i.e., 50 MHz).

It bears emphasizing that there are a large number of factors which can both enhance and diminish coverage and capacity. For this reason, it simply is not possible to compute a single bandwidth factor that can be used to equate coverage and capacity of 800 MHz and 2 GHz systems. Moreover, although it is possible to make technical arguments supporting bandwidths

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[22] The Qualcomm system is a spread spectrum scheme which employs code division multiple access (CDMA) and in which as many as 60 telephone conversations share the same 1.25 MHz radio channel.

[23] See The CDMA Network Engineering Handbook, vol. I, Qualcomm, Inc., November 23, 1992.

greater than 40 MHz, the constraint on available spectrum places a tension between assignment bandwidth and other FCC policy objectives. Thus, despite the technical requirement for greater bandwidths, it would appear that 40 MHz PCS assignments represent a reasonable tradeoff between system economy, diversity and competition.

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In sum, in communications systems there exists a fundamental tradeoff between coverage, bandwidth and channel capacity. Using new digital radio technologies, within certain ranges these tradeoffs can be exploited to partially compensate for the differences in physical properties between 800 MHz cellular and 2 GHz PCS systems. Based on paper analyses and field tests of the Qualcomm CDMA system, it would appear that a PCS system bandwidth on the order of 40 MHz could achieve coverage and capacity on par with a similar cellular system.

IV. ADVANTAGES OF ASSIGNING 40 MHZ DIRECTLY

As is evident from the preceding sections, 40 MHz assignments are absolutely essential to the successful launch and operation of a large scale, effectively competitive PCS which offers a wide array of telecommunications products. Despite the significant advantages of a 40 MHz plan, the FCC is also being

pressured to establish 20 MHz PCS blocs.[24] Narrower assignments would produce a larger number of licenses for the agency to issue thereby providing at least the appearance a policy of fostering ownership diversity.

Policy makers within the agency are considering licensing options which would both satisfy the technical and business requirements for 40 MHz assignments and address the political need to offer a larger pool of licenses. A proposal now under study would parse at least some of the PCS allocation into 20 MHz assignments which could be aggregated into a single 40 MHz bloc. As discussed below, this approach would slow and make more expensive the initiation of service and reduce auction revenues. Moreover, to the extent that 20 MHz blocs may be more efficient in some smaller markets, they can be provided for by adopting a policy permitting partial assignments (i.e., "de-aggregation") of 40 MHz PCS assignments.

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[24] Inasmuch as one would expect rational businessmen to promote their own self interest, the fact that cellular licensees are among those urging creation of 20 MHz assignments further supports the arguments that 40 MHz is required for PCS operators to be effective competitors of existing wireless network operators. If cellular interests truly believed 20 MHz PCS operators would be effective competitors, it would appear to be in their interest to urge the assignment of larger PCS bandwidths thereby minimizing the number of new competitors. See Thomas W. Hazlett, Market Power in the Cellular Telephone Duopoly, August 1993.

A. Spectrum Aggregation is Inefficient

An assumption apparently underlying the aggregation concept is that it essentially is equivalent to licensing 40 MHz spectrum blocs. This is an erroneous assumption. Indeed, as compared to licensing 40 MHz directly, an aggregation scheme would impose substantial transaction costs, delay the initiation of service and lower the proceeds of a public auction.

It has been suggested that, because PCS licenses will be auctioned, an aggregation scheme allows the question of whether 20 MHz or 40 MHz is a more efficient bandwidth to be settled on auction day. The theory is that, if 40 MHz is a more efficient arrangement, bids for a combination of assignments would be greater than those individual assignments. Unfortunately, such a theoretical result could only obtain under conditions of perfect information and in the absence of inefficiencies due to speculators. As a practical matter, one must expect that the auction results will be suboptimal and will be rationalized through post-auction trading. The scale and scope of these aftermarket transactions will be directly related to how closely the auctioned parcels are matched to marketplace requirements.

The fact that assembling spectrum blocs in many markets across the country will impose substantial costs is irrefutable. The magnitude of this cost cannot be estimated accurately, but it

is surely no less than the $1 billion estimated cost of aggregating cellular assignments.

Equally important is the delay in the start of service created by a policy requiring spectrum aggregation. Again, the cellular experience suggests that years can be consumed in the process of assembling licenses. In contrast to cellular where most operations began before system consolidations occurred, however, it must be expected that no PCS service will commence until a sizeable number of 40 MHz assignments have been created. This conclusion is based on the fact that, in many markets, 40 MHz is essential to coordinating PCS systems around existing microwave operations. Given the expected scale economies national operators hope to capture, it is reasonable to assume that operators will assemble a critical mass of markets with 40 MHz assignments before they devote resources to constructing and operating PCS systems.

The transaction costs and delay in the activation of service resulting from the license consolidation required by an aggregation policy would depress substantially the revenues collected from an auction of 40 MHz assignments. In addition to being discounted to reflect the costs of aggregation, bids would also be reduced to account for the significantly increased business risks associated with assembling the needed licenses.

B. A "De-aggregation" Policy Provides for Smaller Assignments, if Appropriate

PCS bandwidth requirements are at least somewhat dependent upon traffic volume, which in turn is a function of market size. Admittedly, a 40 MHz plan matches the traffic requirements of the larger markets. Basing assignment size on large market requirements is good public policy because it recognizes that serving the "critical mass" of subscribers in the urban areas is pivotal to persuading manufacturers to make equipment.

Nevertheless, it must be recognized that, as is true for cellular, a 40 MHz PCS assignment plan might result in an excess of spectrum to operators in smaller markets. As a means of accounting for this possibility, the FCC could adopt a PCS "dis-aggregation" policy and permit partial assignments similar to its treatment today of the SMR service.[25]

The extent to which such a policy was ever employed would depend upon a number of factors, including the relative efficiency gain resulting from a larger pool of licensees. It might be the case, for example, that those very markets where 40 MHz assignments are excessive are also those with insufficient demand to support more than four or five (PCS and 2 cellular) independent wireless networks. In any event, this approach would at least provide a mechanism by which assignment size could be

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[25] See 47 CFR Sec. 90.609(c).

fine tuned, and if economically efficient, new entrants could become PCS licensees.

Analytically, except for the transaction costs involved, aggregation and dis-aggregation policies can be considered identical. A rational approach to choosing between the two is to select the one which minimizes these costs. As discussed above, a 40 MHz plan minimizes costs and delay and maximizes auction revenues. Allowing for licensees to assign part of their 40 MHz bloc is a reasonable means of accounting for any inefficiency which might arise as a result of applying a uniform 40 MHz assignment size to all markets.

V. CONCLUSIONS AND POLICY RECOMMENDATIONS

The new set of wireless, Personal Communications Services (PCS) now being considered by the Commission promises to spawn a wide range of new telecommunications services, affordable to average Americans, while bringing needed competition to cellular and wireline operators. To fulfill this promise requires, among other things, a regulatory regime which expedites system deployment, facilitates effective competition and promotes the development of a network infrastructure that minimizes subscriber costs and maximizes quality. An essential ingredient of such a regulatory regime is the assignment of ample spectrum to PCS licensees. As the preceding analysis demonstrates, 40 MHz